Discussion Paper

Productive use of energy – Lessons (to be) learned in MHP projects

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Table of Contents

1. Introduction

International development organizations and Governments are currently increasing their efforts in utilizing renewable energy sources to support rural electrification. In Indonesia where the hydraulic potential is abundant MHP is acknowledged as possessing great potential for the development of stand alone rural electrification projects and has thus gained significant profile recently. The benefits of providing evening lighting for rural communities are widely accepted as an appropriate measure in alleviating poverty. The issue of how the provision of an energy source can contribute additionally to improve people's welfare and economy, however, is a very relevant question also frequently raised. The application of so called "productive uses" by the beneficiaries is seen as an important output of rural electrification projects when justifying their construction. Hence "productive use" components are included within many rural electrification projects currently implemented.

Evaluation of productive use within numerous rural electrification projects, however, clearly shows significantly lower achievements than targeted. Identifying the reasons why this discrepancy exists is clearly an issue which has not been adequately addressed. Given the level of importance placed on productive use development at MHP locations, a detailed assessment of the limiting factors, successful approaches and the type and volume of resources required to achieve the required outputs is overdue. The present paper intends to contribute to this analysis and summarises crucial conclusions, based on the experience made by MHPP.

The objective of this paper is to present empirical data, information and facts relevant to "productive use" when implemented as part of a MHP project. The information presented should form a basis for further discussions on the theme of productive use components integrated into MHP development projects. This information encompasses technical, social and economic issues deemed relevant to this theme. Examples of activities implemented by MHPP and potential approaches to future productive use initiatives are presented.

2. Background

The issue of productive use is frequently discussed in the context of stand alone rural electrification projects. It is widely acknowledged that the presence of electricity for domestic use contributes to the improved standard of living of rural communities. To what extent access to energy influences economic development amongst the beneficiaries, however, is a frequently debated topic. Proponents of rural electrification claim that through domestic energy consumption (primarily evening lighting) people's education improves, better health prevails and a range of other effects ultimately provide a stimulus to local economies. Others would claim that domestic use of energy is largely "consumptive" and in some cases even leads to negative impacts on the local economy. For example people sitting and watching television rather than engaging themselves in income generating activities. The term "illuminating poverty" (in contrast to "reducing poverty") was subsequently born. Whilst this opinion is hotly contested, it cannot be

denied that for the full economic potential of rural electrification projects to be effected, productive use of energy for income generating activities must be developed to complement the largely domestic and consumptive use during the evening. By increasing use of energy also during daytime, the investment into the power plant is better exploited, which allows for higher revenues and thus an easier coverage of maintenance, repair and re-investment costs.

Understandably therefore, virtually all stand alone rural electrification programs incorporate activities and allocate resources aimed at creating “productive use” of energy amongst the user groups. An energy source can contribute to increased income directly and indirectly: directly through the processing or production of products which prior to having access to energy was not possible or indirectly through the substitution of time consuming manual tasks with more efficient methods utilizing the energy source thus creating opportunity for productive activities.

For either of these approaches to be successful, there are **technical, social, financial, cultural and logistical factors** which need to support the initiative. The success or failure of a productive use will be largely dependant on a positive combination of all these factors. Considering this relatively complex environment, it is not surprising, that levels of productive use applications on rural electrification projects tend to remain low and usually **below the expectations of project developers** (Development Organizations, Governments, NGO’s etc). This highlights the fact that the provision of technical assistance and support must be carefully planned and designed if it is to be successful in influencing what are often very established routines and habits of rural communities. For example if traditional behaviour dictates the processing and marketing of a certain product it may well be very difficult to change the situation. Equally important is an understanding of the technical limitations of stand alone MHP schemes. For example, if the hydrology of a scheme means output is adversely affected during certain times of the year, this needs to be considered when considering productive use options.

Empirical data would indicate that there exists a significant discrepancy between the number of sustainable productive uses actually operating at MHP schemes and the level of expectations on behalf of project developers and program donors. This indicates there is a general lack of understanding regarding the complexity of developing sustainable productive uses at micro hydro power locations in Indonesia. The **specific conditions of the place where a MHP scheme is developed** significantly influences how it will be used. For example rural remote areas in countries such as Nepal and Afghanistan have very limited basic infrastructure and conventional energy sources are prohibitively expensive. Consequently energy produced from MHP schemes is primarily used for important agro-processing tasks (productive use) with the supply of domestic household energy of lower priority. The situation is very different in Indonesia where domestic use is normally the first priority. The following paper presents an overview of productive use using experiences gained through the implementation of the MHPP as a reference where appropriate. Based on the analysis of these experiences a strategy is proposed for the effective and sustainable development of productive use initiatives utilizing energy generated from MHP schemes in rural Indonesian villages.

3. Importance of productive use

Having access to a sustainable energy source contributes in many ways to improving peoples' living conditions. Whilst e.g. evening lighting reduces health risks and improves fire-safety other household appliances such as radios and televisions enable improved access to information and entertainment. These uses whilst increasing convenience and quality of life are still domestic in nature and the extent that they contribute to economic development in the village is questionable. Small scale industrial or commercial uses, however, have a direct positive impact on the economic situation of the users and are thus commonly referred to as "productive uses". Carpenters who are able to use electrically driven tools (electric saws, drills, grinders, sanders, etc), women using electric sewing machines and farmers using agricultural machines such as threshers, hullers and mills for post-harvest agro-processing are able to generate additional income as a result. Traditionally many of these tasks are carried out manually which is often painstaking, time consuming and produces an output of lower quality. Alternatively they are carried out with diesel powered machines which due to the current high fuel cost represent a major financial burden on the villagers. Thus, in addition to **generating additional income, work loads can be reduced, time saved which can be used for education and other constructive activities and more sophisticated products can be produced** through the productive use of energy. The fact that the main domestic requirements for electricity are in the evening (lighting), the daytime hours provide a perfect opportunity for productive use of the MHP facility enhancing overall usage of the scheme and therefore increasing revenues and thus enhancing long term sustainability of the facility.

In particular the **workload of women** can be significantly reduced as it is often them who carry out many of the post-harvest agro processing tasks (grain threshing, milling of flour, grinding of coffee etc.).

Impacts of productive use therefore have a clear relevance in achieving 2 of the Millennium Development Goals (MDG's), namely eradication of poverty by **improving the economic situation** through productive use of energy and **empowerment of women**.

4. Expectations towards productive use

As already indicated above, the main expectation from productive use of energy is the improvement of the economic situation and of the quality of life of the local population. This can be due to:

1. the **introduction of (new) product/s or service/s** which can be offered on the (local) market (e.g. grinded coffee, flour, furniture). This results in a benefit for both, the entrepreneurs / small businesses as well as the customers who are able to acquire products and services locally.

2. the **saving of transport costs** which otherwise would be paid to procure the products / services from outside the village (e.g. in the case of milling, the closest mill may be located some kilometres in a different village)
3. the production of **higher quality with higher added value or larger quantities** of a product (e.g. a carpenter who can start producing sophisticated furniture instead of selling large quantities of (often illegally logged) unprocessed timber)
4. the **reduction of work load** (replacing a manually intensive and troublesome task by a machine)
5. increased revenue of the MHP scheme results in a **more secure and healthy management, maintenance and operation** of the scheme thus enhancing long term sustainability

5. Limiting factors

The limiting factors of productive use depend on general and site specific factors. Besides the fundamental technical limitations inherent of a stand-alone rural electrification project, numerous so called "non-technical" factors need to be considered when attempting to introduce productive use of energy to rural communities.

5.1 Marketing

Marketing issues are crucial factors to be assessed when considering the development of a particular product such as processing raw products into fully finished items (i.e. processing coffee beans and selling them as consumable coffee rather than simply selling the dried beans).

Figure 1: Transport infrastructure is a crucial limiting factor to market a new product

The importance of marketing aspects is often underestimated. It does not make sense to promote the production of something unless the marketing possibilities for this product

are favourable. For example processing coffee may seem a good idea to increase the selling value. However, a multitude of factors will dictate whether this is a financially viable proposition. Is there a sufficient **local market** ? If not, is there reasonable access to **transport** the goods to other areas ? How will the product be packed ? Does this conform to local hygiene standards ? Is there already an established brand of an equivalent product ? etc.

5.2 Culture and traditions

In many remote villages, subsistence farming still prevails. This means most families produce much of what they need by themselves. Introduction of productive use requires a total change of this tradition due to different divisions of labour and trading between families. This represents a major change in their routines which have prevailed for centuries. Naturally this process requires time and patience and can not easily be imposed by outside development agents who are visiting the villages only periodically.

Prior to making an investment into electrical equipment, people first need to build up **trust in the availability / reliability of the electricity supply**. In contrast to an individually operated diesel genset, the functioning of a MHP-scheme is beyond the control and influence of an individual and thus any investment in electrical equipment during the early year(s) after the start of the scheme's operation is a high risk venture which is in most cases mitigated by a **"wait and see how things develop"** approach. In addition to the reluctance of the individual, the community as owner of the MHP system might tend to **"protect" the newly acquired system**, because they have no experience on whether connecting a bigger machine might cause any damage to the system or even completely destroy it.

Regarding diesel-substitution – which in many cases is highly attractive financially, particularly as fossil fuel has become expensive in Indonesia – people remain reluctant to substitute the diesel engine. This can be compared to the situation in Europe where e.g. old energy-inefficient refrigerators are not replaced by new, highly energy efficient ones although the financial benefits are proven. This phenomena is called "non-financial barriers" and is a result of (among others) lack of awareness, **resistance to change a running system**, focus on the relatively high upfront investment costs and not taking into account the much lower operational/energy cost (short term thinking).

5.3 Financial issues

Financial assistance facilities such as conventional bank loans or micro-finance in the "really remote rural areas" are not normally available. Even if such programs exist in the larger urban centres this does not (yet) mean that rural people are able to **access** them due to inadequate **collateral** (no land titles) and the fact that banks are simply not familiar with dealing with rural villagers.

Compounding this situation there is often a **lack of information** regarding which electrical devices and at what costs (investment and operational) are suitable for a specific task. And if found equipment which would from a financial point of view be preferable compared to the status quo, still the limited access to financing prevents the interested persons to be able to mobilize the required (high upfront-) investment.

6. Technical options for productive use

Generally speaking, there are two options the so-called "direct drive" and "electrical drive". Both have advantages and disadvantages.

6.1 Direct Drive

With **direct drive,** the machine is driven directly by the turbine via a coupling or a belt and pulley transmission. The main advantages of this arrangement are:

- technically relatively easy to handle because purely mechanical drive (robust)
- no motor required to drive the machine→ lower cost
- high efficiency (less conversion losses)
- system can also be controlled manually → lower cost

The disadvantages of direct drive are:

- machine has to be installed in the powerhouse (mostly unfavourable if the powerhouse is far away from the village or otherwise difficult to access due to its specific topographic location)
- in general, simultaneous operation of generator and machine not possible (either operation of machine/s or production of electricity through the generator)

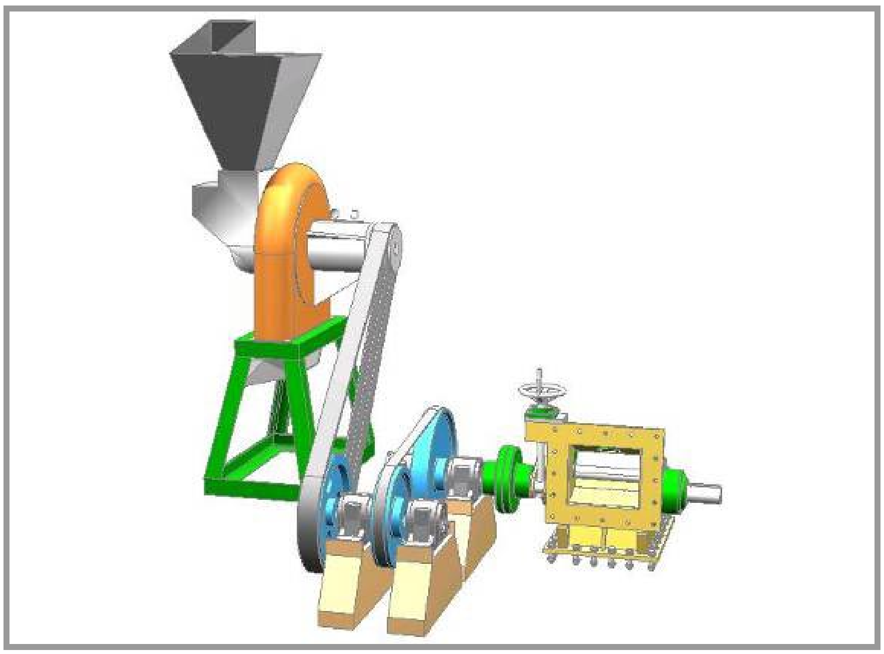

Figure 2: Schematic illustration of a typical direct drive application

6.2 Electric Drive

Electric drive means that a machine is connected to the electricity grid at some point in the network. Main advantages of this option are:

- higher versatility because machine/s can be installed (almost) at any place
- in general, simultaneous operation of generator and machine is possible (depending on the load of the machine)

The disadvantages of electrical drive are:

- technically more sophisticated, can be more repair intensive (depending on quality and sizing of the electric motor)
- electric motor required to drive the machine → higher cost
- lower efficiency (mechanical energy transferred to electrical and then back to mechanical → higher conversion losses: 30-60 % losses of available shaft power)
- size of generator, and possibly turbine, must be significantly above that of the motor load. A problem arises if the rated power input for the machinery represents a significant portion of the generator's capacity. Depending on its characteristics the motor can need a 3-5 times higher power input for starting (so called "surge-current")!
- especially in isolated small grids a load control system is required (e.g. Electric Load Control ELC) → higher cost
- for loads which require higher power, a 3 phase supply is needed meaning that a 3 phase distribution line must be installed to reach to the end use application.

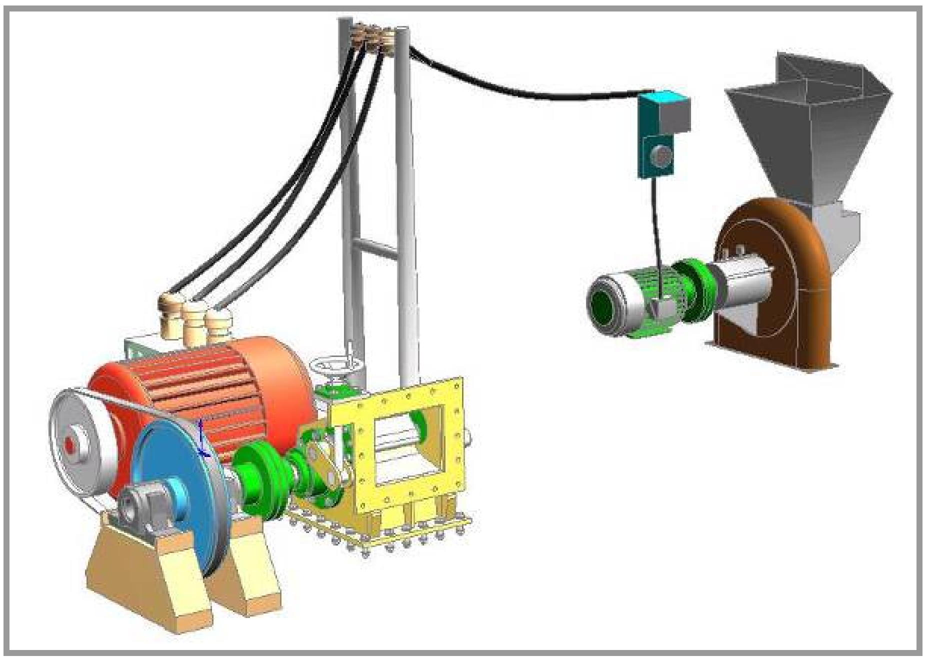

Figure 3: Schematic view of a typical electrical drive arrangement

Any **change in load** as a result of consumer behaviour within a stand alone scheme has an immediate and direct influence on the entire system. The larger the change the more relevant the impact. For example a fluctuation of 1% of the total load may be insignificant, however, a change of 10% would have serious consequences for the other users. This is not normally the case for grid supplied villages where their total supply represents only a small fraction of the total grid capacity and therefore any change in load is negligible. To compensate these load fluctuations, a proper **control system** is required.

If electricity is only used for **lighting, TV's and other very small domestic appliances**, neither sophisticated flow control nor load control is required. The system can be **controlled "manually"**. This means the operator goes to the powerhouse periodically and adjusts the voltage to the required level by opening and closing the turbine guide vane / valve. For starting and operating this type of system the consumers are required to leave all appliances (mainly lights) switched on thus keeping the load constant.

For **productive use of electricity**, e.g. agro-processing such as threshing, hulling, milling etc, as described above, the critical factor to be considered is the issue of **load fluctuation and start up loads**. Where the rated power input of machines exceeds a specific proportion of the generators output capacity, these loads cannot simply be connected and operated "anywhere" in an isolated grid network.

In general, to facilitate the flexible use of appliances with higher capacities (e.g. bigger agro-processing machines as mentioned above or even smaller appliances like rice cookers, coconut rasping, angle grinder etc.), load fluctuations provoked by switching on and off such machines must be outbalanced within the system. As mentioned above, manual control is only applicable in the case of a relatively stable load pattern, i.e. electricity used for lighting where lights are not switched on and off. The most common approach to avoid such fluctuations is with the use of an **Electronic Load Controller (ELC)** which keeps voltage and frequency at a constant level. Output of the generator is kept constant and any surplus energy which is not immediately required by the users is diverted by the ELC to an electrical ballast load, normally an air or water heater which in most cases is installed directly in the power house.

The second limiting factor associated with electrical drive is the simultaneous usage of household appliances and domestic load with productive use equipment. Such a situation can result in a **system "peak" load** which if exceeding the generation capacity of the scheme will result in overload condition. Even if the hydraulic potential was sufficient constructing a **scheme able to cover such peak loads** may well **not be economically viable**. To avoid such a condition a **load management arrangement** is required. A typical load management set up is illustrated in *Figure 4* below.

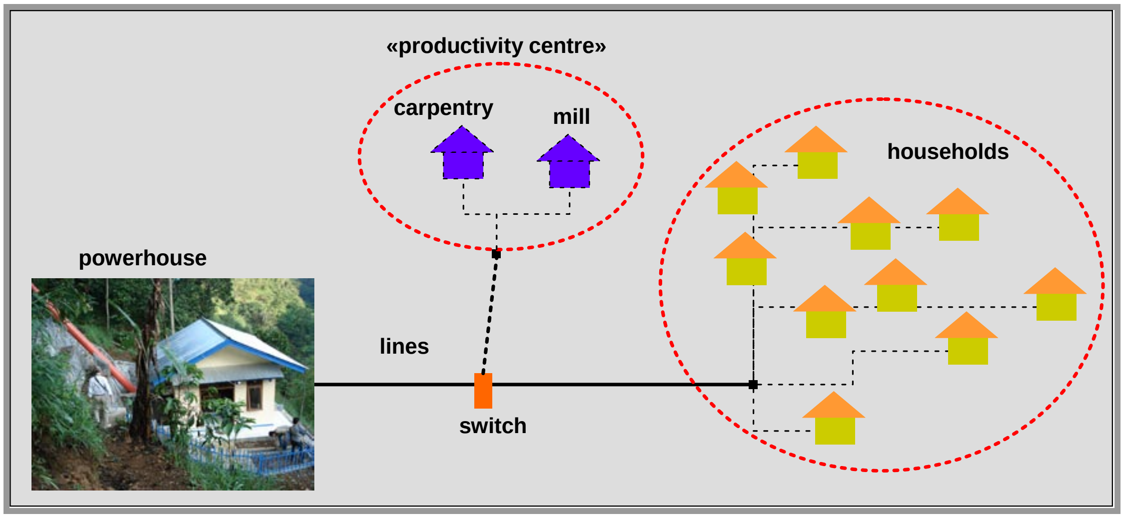

Figure 4: Recommended network design to facilitate effective load management

With such an arrangement certain **times of usage** of electricity have to be defined for the 2 user groups. For example the mini "productivity centre" would be permitted to use electricity between 9 to 12 and 14 to 17 o'clock, whereas the households would be allowed to use electricity for the remaining time. By means of a **main switch**, as shown in *Figure 4*, such an arrangement would be possible. Where such a set up is geographically not feasible, this arrangement could still be applied, however, the household consumers would have to be very disciplined and adhere strictly to the agreed usage times. In many rural environments particularly where the consumers houses are widely scattered, achieving a disciplined approach to energy consumption can be difficult. Regardless of how the arrangement is achieved, day-time productive use, be it with or without spatial separation, will **increase the load factor** of the system and – unless peak demand is not increasing beyond a critical threshold – is therefore **improving the economic efficiency** of the whole project.

The two technical factors described above are extremely important from the energy supply perspective as they will define operation optimization and thus economic performance of the system. From the consumers' point of view it is critical that they can rely on a **satisfactory and reliable supply**. To achieve this, access times must be well defined and strictly adhered to. Any disturbance to the public's service as a result of productive use initiatives may well have a negative effect on the consumers' willingness to pay and their general attitude to the management of the scheme. Productive use initiatives **operated by village institutions** (i.e. small-scale electricity utility owning and operating the MHP) are much less likely to create social problems in the village than those **operated by private individuals or small businesses** who are anyhow often suspected of exploiting the villagers. In particular fully "commercial" initiatives who effectively compete for **year round availability** of electricity (at least at fixed times of the day / week) to run their businesses have a greater potential to create social conflict. Consequently such arrangements need to be managed very carefully and the potential risks and benefits for the village community need to be pointed-out in even more detail.

7. Institutional set-up & initial investment for productive use

Even where villagers have ideas on how to use electricity in a productive way, they frequently do not have **sufficient investment capital** or **small scale industry experience** to realize these plans. Given this scenario, efforts to accelerate productive use development must address the issue of financing. MHPP's major target areas are remote rural areas in which banks typically do not provide investment capital and micro finance organisations are not (yet) available. Under the absence of such commercial lending facilities, e.g. the direct provision of a portion of the required investment capital as a grant is one option. Under no circumstances, however, should the provision of grants be used to cover operational costs. Regarding ownership models, both **private and community based initiatives** should be considered when assessing productive use options. Although privately owned initiatives are in general operated more efficiently, the issue of possible social conflict arising as a result of support given to specific individuals should be carefully considered and not underestimated in the Indonesian context.

The vast majority of MHP systems assisted by MHPP are **community systems** which are owned and operated by a village who nominates the staff (operators, book keeper etc.) to operate and manage the system on behalf of the community.

Community-based organizations (with their so-called UPT = "Unit Pengelolaan Turbin" = turbine management unit) owning and operating the MHP system are ideally positioned to own and operate a productive use facility. A publicly owned facility is able to provide services to all members of the community at reasonable tariffs therefore providing a benefit to both consumers and the UPT who will receive additional income. Provided **privately owned productive use initiatives** adhere to a suitable set of rules and their energy use does not detrimentally impact the other consumers, their presence can enhance significantly income generated by the scheme. This in turn indirectly benefits the community through enhanced financial sustainability of the scheme. The following illustrations present **various models** which could be appropriate for productive use initiatives depending on the specific nature of the respective villages.

So far, the **experience** of MHPP with productive use since the start of the EnDev-project phase (2006) is **limited to productive use facilities owned and operated by the community**, as shown in *Figure 5.*

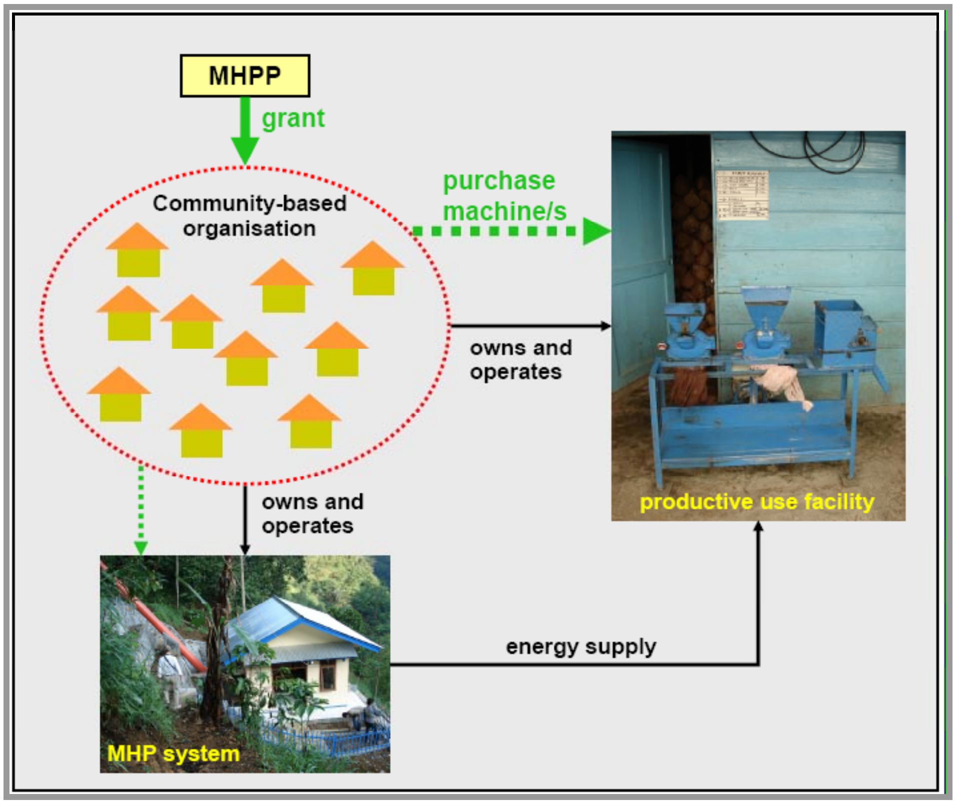

Figure 5: Productive use facility owned and operated by community[1]

In the event that a private individual is interested to start a business utilizing the available electricity, a grant for initial investment of equipment could be made available whereby **ownership rights of the equipment remain with the community** (UPT) with the operation carried out by the private. The model would therefore be **private operation** of community-owned machine/s based on:

a) a service contract or

b) a leasing contract.

Thus, the community organization receives a grant to finance the purchase of a machine whereby a private through a service or a leasing contract would operate and run the facility, as presented in *Figure 6*.

[1] Green arrows reflect the flow of funds (originally) contributed by MHPP.

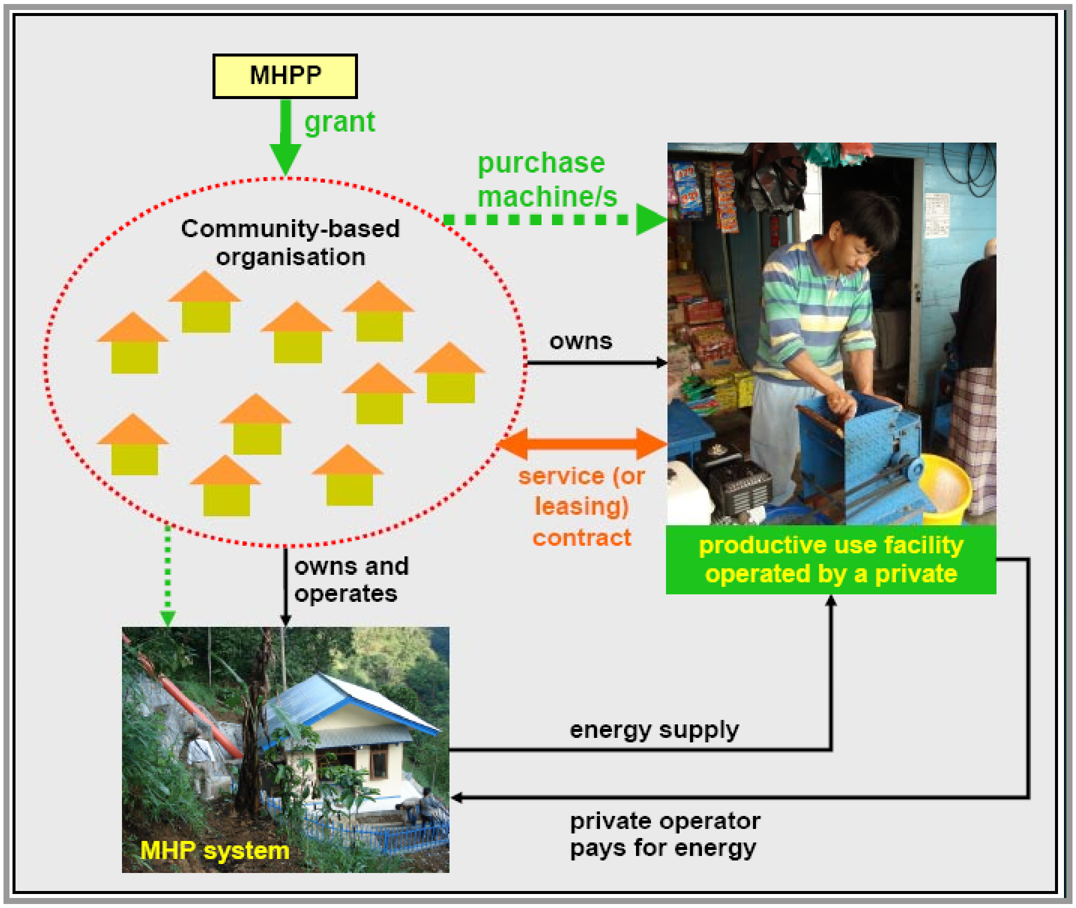

Figure 6: Productive use facility owned by community but operated by a private

In many villages, productive use facilities, especially mills driven by a diesel genset, were already operating before the installation of an MHP system[2]. In that case, it must be analysed if it is technically and economically viable to either couple the **existing machine** with the turbine (direct drive) or to add an electric motor to connect it to the network, thus **substituting the diesel genset**. Although at a first glance substituting diesel with renewable energy for such tasks is an attractive option, the viability of such a conversion depends on many factors as described in chapter 6. These include the ability of the scheme to supply the required capacity throughout the year, required investment, start up load, capability of the scheme to handling fluctuating loads etc. If the replacement is deemed viable the investment required could also be considered eligible

[2] The existence of (mostly) diesel driven productive uses prior to the MHP-installation poses a big challenge in the Indonesian context: Indonesia has a strong culture of imitating assumedly successful business approaches. Instead of being based on an analysis which would try to explore why "the original" became successful the imitation is to a large extent only based on what can be seen at first glance from the outside. When it comes to productive use of energy in a remote village, the "successful original" is almost in all cases using a diesel-driven system. Before not having persuaded the owner of the original to replace the diesel-system by MHP, it is often next to impossible to convince any of the potential newcomers to start-up their productive activities by using MHP from the outset.
Within EnDev however, diesel-based systems are per definition a form of modern energy. Thus, the extremely time consuming but necessary effort of persuading an established productive user to change over to MHP does not even count as an outcome within EnDev.

for grant support, provided that even for the already established (and thus in many cases wealthier) entrepreneur other sources of finance (e.g. equity or commercial loans) are not accessible.

For a private entrepreneur, the support should then **be channelled in form of a grant to the UPT** as presented in *Figure 7*. This approach ensures that by paying back the (soft) loan to the UPT, the benefit reaches the community as a whole and not only a private individual, as already described above.

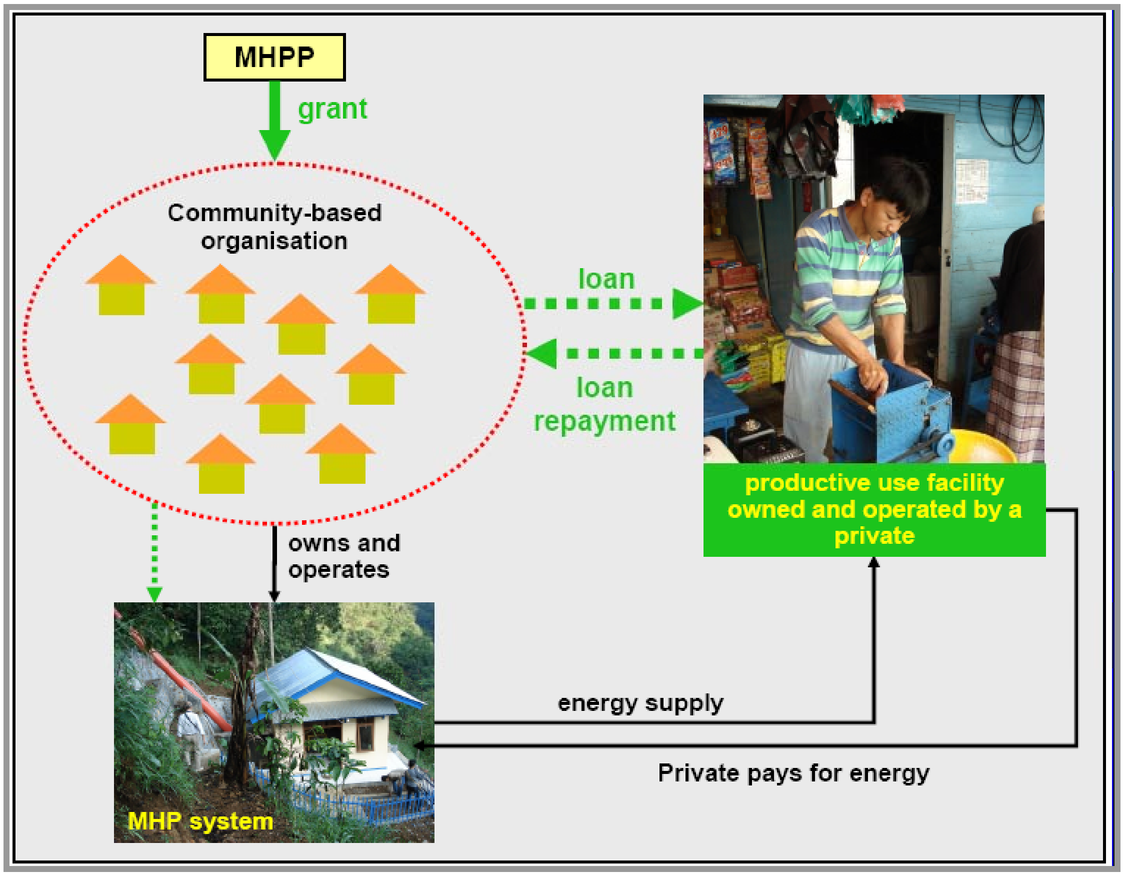

Figure 7: Productive use facility owned and operated by a private

It may happen that by supporting the development of community-owned productive use facilities, **competition for existing business** is also created. For example, if a private person owns and operates a rice mill operated with a diesel genset her/his business might be disrupted by a community owned grant-financed mill working with cheap energy from hydropower and thus offering a low-priced milling tariff. In such cases, no general solution can be pre-defined. It is rather recommended to analyse each individual case in detail, **discuss and consider it in a participatory process with the community** in view of a reasonable solution satisfactory for all parties involved.

8. Specific activities of MHPP

Based on the experiences made so far, MHPP is facilitating and promoting productive use of electricity through the implementation of the following activities:

1. **Addressing the inherent technical limitations** of stand alone MHP's (e.g. solution for easy load control[3], application of MCB's for load management[4] etc.) which ultimately define compatibility with specific productive use applications.
2. **Promotion and awareness building** of productive use options at MHP sites by means of village meetings, presentation of videos and case studies, discussions with villagers on the specific potentials and demands at each site
3. **Presentation of typical "cash flow analysis"** for envisaged activities highlighting the financial impact productive use can have on a schemes finances (see *Figure 8*). This includes presentation of a graph clearly illustrating the expected cash flow, depending on certain input variables (salary of operator, costs for repair, price for milling etc.)
4. **Provision of part of investment capital and technical assistance** to UPT's for adding agro-processing equipment to existing MHP's (4 completed in West Sulawesi[5]). Villages are encouraged to **prepare and submit proposals** as a basis to receive such support.

As mentioned in the chapters 2 and 5, the marketing and access to markets is often the primary limiting factor in the development of new products / services. Therefore, as a general rule to optimise the success of activities and to minimise the risk of investment the project is prioritising the **support of already existing activities** (e.g. threshing, hulling, milling etc.). It is hoped therefore that where existing agro-processing tasks are being carried out "manually" or with diesel powered engines, these can be converted and driven with hydro powered machinery if technically viable.

The following table and the graph provide an example of a cash flow illustration as it is used during discussions on productive use held in a village. The format facilitates the changing of key figures such as operator's salary, tariff levels, quantity of output and other variables. A simple sensitivity analysis can then be illustrated showing the impact on the overall cash flow when one or more of these figures change. In the example below, it is assumed that the initial investment (for the mill) is paid fully by the future owner, in this case the UPT (without any subsidy). Any grant support would of course further enhance the cash flow curve.

[3] As described in chapter 6, flexible use of appliances with higher capacities is only possible if load fluctuations provoked by switching on and off machines are outbalanced within the system.

[4] So-called MCB's (mini circuit breakers) are a kind of fuses which switch off as soon as the specified current is exceeded. MCBs available on the Indonesian market especially in the lower range are not very accurate and therefore cannot properly limit the current / power available per household. If the MCBs would work accurately households which are interested in smaller appliances for productive use could be controlled with the respective MCB and pay a higher tariff accordingly.

[5] Two of them have already proven their smooth operation and management.

expenditures for productive use		
investment (e.g. rice milling machine)	**12,000,000**	Rp
year of investment (year after start of MHP operation)	2	
Operation, maintenance, periodic refurbishment		
salary for operator	**50,000**	**Rp/month**
consumables, spare parts	1.00%	per year
major repair	2.00%	every year
	25%	every 5 years
revenues from productive use		
price for 1 unit (e.g. Rp/1 kg of milled rice)	**550**	**Rp/kg of rice**
amount of units sold per month (e.g. kg rice milled)	600	kg/month
number of (processing-) months in 1 year	8	per year
yearly price increase for processing	**10%**	

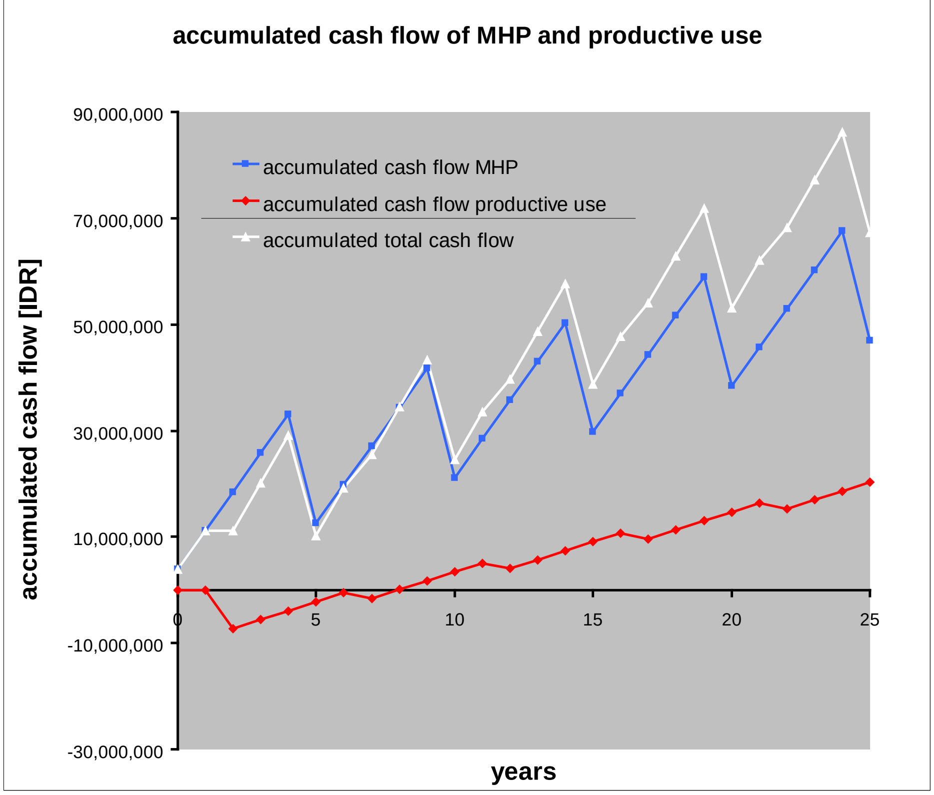

Figure 8: Example for projection of accumulated cash flow for productive use (rice mill)

To encourage and simplify the process for the submission of proposals from villages a standard template has been elaborated and is provided to the village during the promotion campaign on productive use which defines the major **components and aspects to be addressed in a proposal**:

- Who is the applicant (community based organisation, private business person etc.) ?
- Number of potential future users of the machine/equipment ?
- What quantities will be processed (e.g. what is the yearly coffee harvest and how much will be hulled, fried, ground) ?
- What is the current price of the service in the area (e.g. how much do you pay in neighbouring villages/towns for the specific service like coffee grinding, what are the additional transport costs which could then be saved in the future) ?
- How many competitors are within reach who offer the same service / product ?
- What are the investment costs for the required machine / equipment (+ transport cost + installation cost) ?
- What is the applicant ready to contribute (cash, installation work…) ?
- Suggestion regarding (electricity) tariff which would be applied for operating the machine and the tariff for the service itself (e.g. price for grinding 1 kg of coffee) ?
- Suggestion on how to operate and manage the new business (who is the owner / community owned, who operates the machine, who manages the funds and how ?)

9. Exemplary implementation

MHPP has supported the implementation of approximately 20 micro hydropower schemes in Sulawesi since the start of the EnDev project in 2006. All these systems are **community owned and operated**, through a village unit established specifically for this task. This "turbine management unit" UPT normally comprises 2 operators, a bookkeeper, a secretary and a head of management which are all elected by the village and receive a salary according to their respective tasks. In two of the villages, namely Lisuan Ada and Minanga, productive use of energy "pilot installations" have been successfully implemented. An overview of these initiatives is presented below.

9.1 Lisuan Ada

The MHP system in Lisuan Ada with a power output of 8 kW started operation in Sept '06. It currently supplies 91 households with evening lighting. The UPT established a tariff system based on the number of lamps installed (fixed fee) per house. They also have a system whereby customers pay a fine for late settling of their electricity bill. All excess revenue after the payment of salaries and maintenance is deposited on a bank account, opened especially for the UPT. After one year of operation the bank savings

amounted to more than 3 million IDR (230 Euro). An amount of 1.6 million IDR was budgeted by the UPT for the installation of a huller and a thresher. The total cost of the two processing machines was approximately Rp 20 mio (EURO 1,500). This was provided as a grant contribution by MHPP. All local costs incurred in the installation were covered by the village UPT.

Figure 9: Thresher and huller installed with direct drive in the powerhouse in Lisuan Ada

The two main considerations when choosing the "direct drive" option rather than electrical were that:

1) the huller consumes almost the total available shaft power therefore would be difficult to supply electrically
2) the powerhouse location is close to the main village road has relatively good access. The fact that both the thresher and huller are installed in the powerhouse has the advantage of the villagers being able to bring the harvested paddy directly to the powerhouse and have it threshed and hulled at the same time.

On average the machines are operated twice a week during the daytime hours. The UPT operate the MHP for lighting between 5 o'clock in the afternoon and 7 o'clock the following morning (except Sundays when they provide a 24 h supply). This means that during daytime energy is available for other purposes, namely threshing and hulling. A fee of 10 % of the hulled grain is retained by the UPT. This is a fairly standard fee for milling in rural Indonesia.

Before the use of hydropower, all threshing and hulling was carried out manually, in general by women. This is a very labour intensive time consuming process.

Figure 10: Woman hulling paddy manually in West Sulawesi

9.2 Minanga

In the village of Minanga, a 10 kW MHP scheme supplying 45 households has been in operation since July '06. After one year of successful operation, a rice huller was added to the scheme installed within the powerhouse utilizing a "direct drive" from the turbine. Similar to Lisuan Ada, the cost of the equipment was covered by a grant from MHPP with the UPT covering all other costs for the installation. Ownership and operation of the MHP scheme including the huller is community-based.

Figure 11: Rice huller in the powerhouse utilizing a "direct drive" from the turbine

10. Summary on crucial issues

Experience gained from MHP programs not only in Indonesia conclusively shows that productive use of energy / electricity can be successfully integrated into stand alone MHP schemes resulting in increased welfare and economic activity in the respective villages. However, the inherent complexity of developing such activities within a decentralized community managed "stand alone" energy project makes this an often time consuming and complex undertaking. Ultimately it requires the fulfilment of various criteria - technical, financial and social - for this development to take place. In most cases it is not one single factor which determines the suitability for a specific end use to be introduced, but rather a combination of a number of different factors.

The main opportunities for the development of productive uses at MHP locations are agro processing, small scale service providers (shops, repair workshops, carpenters) and diversified domestic applications (rice cookers, blenders etc). For the traditional types of **agro processing end uses** both direct and electrical drive arrangements can be applicable. The other predominantly **"household" based applications** rely exclusively on the supply of electric power. These include small scale cottage industries such as sewing, embroidery and other handicrafts for which the products can be sold as a source of income. The substitution of traditional energy sources with electricity for domestic tasks such as cooking, food preparation, laundry etc. can also be interpreted as **"productive"** not only where they result in **clear economic benefits** but also where they significantly **relieve from work load**, the latter being an important precondition to develop new business ideas.

The fundamental factor which differentiates the "stand alone" environment from the "grid supplied" equivalent is that any change in load as a result of consumer behaviour within a stand alone scheme has an immediate and direct influence on the entire system. The larger the change the more relevant the impact. However, with an **appropriate load control system**, productive uses of many different sizes and configurations can be accommodated even within a stand alone environment.

The diverse and specific nature of remote villages in Indonesia means that the environment in one village can be very different from the next. This factor limits possibilities for developing standardized "blueprint" approaches to developing productive uses.[6]. Instead, the **specific conditions for viable productive use activities must be analysed on a "case to case" basis in close cooperation with the community members**. Assuming a proposed productive use is technically viable, the subsequent non-technical criteria must be carefully assessed. This includes the issue of ownership, responsibility for operation, consideration of competition to other service providers,

[6] Following the EnDev-criteria of "providing energy only in cases where there was no supply of modern energy before" MHPP is forced to work in places with very poor infrastructure. This low level of infrastructure often not only stems from the geographical remoteness of these villages but also from the fact that they are inhabited by ethnic and/or religious minorities which do traditionally not enjoy highest priorities from the government. When considering the large heterogeneity among Indonesia's many different ethnic groups the limitations to getting closer to a one-size-fits-all-approach become even clearer.

implications on other users etc. These are all potentially sensitive issues particularly in a rural environment.

The main conditions dictating the **viability of a specific productive use** activity include the following:

- Careful assessment of **technical** suitability of the proposed application
- Build up on **existing activities** and benefit from experiences rather than starting a completely new business
- Establishment of a **cash flow estimation**
- Consideration of **potential competitors**
- Clarification of **ownership**
- Clear assignment of **responsibility for operation**

Where these criteria are adequately considered, successful examples have been developed where productive use is contributing to the improvement of villagers' welfare. The **pilot agro processing installations** described earlier in chapter 9 although still relatively recent, clearly prove such types of productive use can be successfully integrated into MHP schemes. Particularly relevant in this case is that by substituting traditional agro processing methods such as hulling with mechanized alternatives a significant amount of manual labour in particular for village women who predominantly carry out these tasks can be reduced.

Feed back from the monitoring of other sites supported by MHPP also indicates that **small scale household productive uses** such as rice cookers, blenders and other kitchen appliances are becoming more commonplace amongst rural communities.

Based on the implementation experience, also from other projects, the general conclusion can be drawn that overcoming the technical, social, logistical and economic barriers for successful introduction of productive uses at MHP locations is a **highly complex, time and resource consuming task**.

Under the current phase, the project will continue with the 4 core activities as described in chapter 8, namely **optimisation of technical preconditions, promotional activities, specific advisory service and encouragement for submission of proposals and the support of partner**[7] **initiated pilot projects**. Thus, the number of projects where productive uses can be adopted will mainly depend on the success of the promotion campaigns and the resulting number of proposals submitted by partner organizations committed and capable of facilitating this development with the respective villages.

[7] Such partners are other development organizations/projects, local governments, NGO's etc.

11. The way forward on productive use development

Certainly, numerous successful examples provide justification for the continued promotion of productive use. However, given the significant disparity between program expectations, and the scale and type of resources required to achieve these, the general approach towards productive use development needs to be discussed.

Instead of focusing only on energy used by formal and informal SME (small & micro enterprises), a common understanding should be built that **any use of energy which can relieve work load also deserves being labelled as productive**. E.g. a blender or a grinder used in a private household frees up precious time for more joyful activities thus contributing to the ultimate goals of economic development.
Any kind of **household lighting** which allows pursuing home industry (e.g. weaving) during evening hours should also be considered as productive[8]. It might – to a certain extent – even be justifiable to attribute "common lighting" in farm households to the productive use category. This is the case when improved lighting inside the house allows the farm-family coming home later from their field work, thus having a bigger agricultural production.

Furthermore it needs to be discussed **what can realistically be achieved** (as a function of a certain input, i.e. money and time). Since the issue of productive use is not only relevant in the context of stand alone energy schemes but also applies to rural communities having access to conventional grid supply, the development of productive use within such environments could be taken as a reference for defining goals and expectations. When taking into account the even more problematic circumstances of remote "stand alone" energy systems, the dimension of the challenge should become comprehensible and eventually lead to a balanced relation between resources and expectations.

Based on the experience gained so far the implementation strategy should include the following aspects:

1. To fulfil the **technical pre-conditions** for integrating productive end use follow-up the continuous improvement of appropriate control systems (e.g. ELC). To meet customers' requirements in terms of product specifications and after sales service, capacity of *local* manufacturers needs further development.
2. Further **capacity development of project developers and practitioners involved in promotion** of productive use in the villages, regarding technical preconditions for productive use, load management, administrative and financial aspects, good practice examples etc.

[8] In this context it is important to notice that in remote villages there is no strict distinction between work place and home. Activities – also the purely work related ones – which require a building / roof / dry and clean floor etc. are carried out at home, emphasizing the fine line between productive and domestic categories.

3. Application of a strictly **participatory approach**: to encourage and assist the community in developing productive use applications which cover their specific needs. If a genuine commitment from the villagers is not yet apparent, the project should not impose productive end use activities from outside.
4. Establish **synergies with other rural development programs** for combining and optimizing respective resources. In this context, MHPP's foreseen cooperation with the national PNPM program provides a promising opportunity to address this issue in a more comprehensive way.
5. Support the **inter connection of MHP's to the PLN grid** in order to generate income for rural communities by sustainably harnessing their natural resources.